AN INTELLIGENT IoT BASED ENERGY MANAGEMENT SYSTEM FOR ISLANDED MODE PHOTOVOLTAIC SYSTEM

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

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by

Hardev Meena
Registration number: 18/Ph.D/067

Under the supervision of
Dr. Leena G.
Professor, EEE Department

FACULTY OF ENGINEERING AND TECHNOLOGY

MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH & STUDIES

SECTOR-43, SURAJKUND –DELHI ROAD, FARIDABAD – 121001

FACULTY OF ENGINEERING AND TECHNOLOGY

Certificate

I hereby declare that the short synopsis "**An Intelligent IoT Based Energy Management System For Islanded Mode Photovoltaic System**" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in EEE under faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2019-20.

It is a bona fide record of original work carried out under the supervision of Dr. LeenaG and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

(Hardev Meena)
18/Ph.D/067

Signature of the Supervisor
Dr. Leena G, Professor, EEE Dept.,
FET , MRIIRS

(Chairman, DRC)
Dr. Anita Khosla,
Professor & Head, EECE Dept.,
FET, MRIIRS

Chairperson, CDP

ABSTRACT

Energy consumption is key factor to decide the growth rate of any developing country. It is the condition which can be directly or indirectly effect by the availability of natural energy resources, power generation, transmission and distribution. Power generation by using conventional resources is limited, hazardous for environment and less economical. Power generation and utilization could make environments supportive, economic and consumer pocket by adopting the renewable energy sources (RES). Adoption of RES system depends on local environment situations like solar irradiance and wind speed. Small electrical power station/Distributed generation (DG) or Microgrid independent on traditional grids etc., are located on the user side to meet end user demands. Access of solar energy is easy to each consumer everywhere. But main challenges are efficiency, control, reliability of Photovoltaic (PV) System. All drawbacks can be overcome by making system intelligent with Energy Management. It require availability of data, continuous monitoring of devices and overall system/plant. Smart system may be possible only by integration of sensors and internet of thing (IoT). An Intelligent IoT based Energy management system (EMS) helps the islanded mode Photovoltaic System (PV) economic, environment supportive and technically smart by performance optimization, monitor and smart control. Proposed concept developed by environment study, load identification and smart socket concept. The Internet of Things (IOT) based EMS coordinates the optimal power flow, provide convenient load shedding, power source management, data acquisition and automated control of the networks. The intelligent EMS is proposed to self diagnose the normal and abnormal conditions in the network. During any abnormal/fault condition the loads are automatically disconnected and information/message send to user. The proposed research is to carryout according to data base developed model, simulation (MATLAB)/experimental setup for practical implementation. Simulation (MATLAB)/practical set-up are carried out to evaluate under IoT environment and smart monitoring devices (SMD).

Keywords: Renewable Energy Sources, Microgrid, Traditional Grid, Island mode PV system, Smart System, Internet of thing, Energy Management System, smart socket, MATLAB,

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1. Introduction

It is required to fulfill continuous increasing demand of consumer like smart house, electric vehicle and electrification of transportation without effecting environment of surrounding. This kind of concept is possible only by adopting renewable energy source (RES) like wind energy, solar energy and biomass etc. Adoption of RES system depends on local environment situations like solar irradiance and wind speed. Small electrical power station/Distributed generation (DG) or Microgrid independent on traditional grids etc., are located on the user side to meet end user demands. Due to small size DG systems has high flexibility and satisfy the load demand and solve the long distance transmission loss and power quality issues. PV system is controllable entity for the user side; it can meet load demands, reduce losses and provide local voltage stability. PV system connected to grid through power electronic converter to regulate the active, reactive power and output voltage to improve grid reliability. A Microgrid operate as

a. Stand-alone (Island) Mode
b. Grid connected Mode

Designing of a microgrid is taken care of with dynamic impacts on basic grid like stability, frequency, impedance matching and reliability of the complete system. Microgrid is classified into: AC microgrid, DC microgrid and AC/DC microgrid as per current and voltage. DC microgrid deal with loads through the DC bus and a suitable converter and AC load via an inverter. In islanded microgrid all generation connected to common grid through converter and there is no inertia of rotating mass to affect the frequency. In such cases frequency is developed by a power electronic device. Due to load demand small size renewable energy sources penetration is increasing day by day into existing grid and created new issues for power system. The coordination of sources and load can be based on either a decentralized or a centralized approach. There is option to bidirectional DC/AC converters for AC grid interconnection. The power storage management is required to smooth the power output from PV system. The microgrid protection and operation is based on microgrid monitoring like voltage, current, frequency, real & reactive power control/regulation; load/weather forecasting, load shading. In general, the hierarchical control schemes have three levels:

a. The Primary level: Local control

b. The Secondary level : primary deviations in variables like frequency and voltage
c. The tertiary level: the energy management system

An energy management system (EMS) is introduced to automate real time system for optimal schedule and management of PV system and controllable load. The EMS deal with data management, grid information, supervision and control. The major functions of EMS are –

a. Increasing the system reliability by maximizing each consumer energy availability
b. Minimizing operation cost, energy losses, gas emission and fuel consumption.
c. Maximizing the use of RES
d. Minimizing the energy purchased outside the grid
e. Efficiently managing the all loads

To manage such major function an energy management system requires some kinds of data input –

a. Forecast of the renewable resources
b. Forecast of the Electrical load and weather
c. Demand side management
d. Power flow module
e. Load leveling and peak shifting
f. Centralized and decentralized energy management
g. Fluctuation suppression (intermittency Mitigation
h. State – of – charge (SOC)
i. Security and reliability constraints of the network
j. Information about the common coupling with main grid

A set of control action required all this data gathered by EMS. IOT is a concept, which connects any device to communicate and control with an ON/OFF switch and collect data through the Internet and make reachable to each device. Basically it allows device to be remotely accessed, controlled and monitored through the sensors across the concerned network. Also it make system durable and robust to provide more integration between the existing physical network and computer based automated system thus creating the system economical, efficient, stable and accurate.

2. **Literature Review**

Elmouatamid et al. (2019) suggested in their comprehensive study that Demand/Response IoT base control strategy to balance the power flows between PV, batteries and the traditional energy generation. Prediction models are compared in terms of Mean Absolute Error and Percentage Error performance metrics. IoT environment is integrated for system monitoring and further data analysis (Pawar & Tarun 2019). IoT based EMS is designed to access standalone photovoltaic system with hardware setup (Swathika & Hemapala 2019) which set load priorities, data acquisition and provides proper load shedding. Spanias (2017) suggested a solar energy IoT scheme is provide mobile analytical, programmable, solar farm control that detect and remedy faults, optimize power generation according different shading conditions and minimize inverter/converter transients. IoT enabled panels with new experimental facility is also suggested. Kalezhi et al. (2019) suggested in their comprehensive study that the architecture for allocation of energy to devices based on their demand and importance based on IoT infrastructure. Gil et al. (2019) suggested in their study that IoT technology with advanced control strategies, like Model Predictive Control (MPC), to develop efficient methods to manage the Solar Membrane Distillation (SMD) plants and greenhouses.

The drop across Low Dropout (LDO) regulators change according to ambient condition and the power extracted is dissipated within the Low Dropout, resulting in reduced overall efficiency. Basic important factor is that it mostly utilizes two DC/DC converters even there is more than sufficient ambient energy to supply the connecting load circuit. To address such issues, an intelligent architecture has been proposed by (Mondal & Paily 2017). The IoT devices are used for making smart home by accommodating the appliances information and communicating via the internet to the green homes and networked control system using cloud server (Rana, Bo & Chen 2019).

A generic approach is proposed by Ha & Phung 2019, for improving reliability and resilience of a complex system, with renewable energy of a smart building, where the obtained results are also scalable to apply for either to a single house or a number of buildings. A real time monitoring system based on IoT was developed by Khan, Sharma & Haque (2019) which help to find faulty solar panels, system connectivity, and dirt on solar panels, and hence improve the solar plant performance.

Zia et al. (2019) aims to provide a comprehensive understanding on Microgrid Transactive Energy System (MGTES). The architecture and market prospect of MGTES is presented.

Veena et al. (2019) suggested in their study that the complete design and operation of IOT based automatic water pump controller from the engineering perspective and created an enhanced working model of water pump controller integrated with sensors having significant improvement.

Shivashankar et al. (2016) suggested in their comprehensive study that problems introduced due to intermittency in solar energy connected to grid and suitable methods may be adopted to minimize the fluctuation in voltage and power output of PV system.

3. Research Gap

Renewable Energy help to make healthy environment, reduce the human effort, fulfil the requirement of energy and make system economical as well as reliable for consumer. In this process it required some extra arrangement like forecasting, load study, controller and set of smart devices which can help to system become intelligent. In this subject many researcher's has submitted their opinion and algorithms. But some issues are still challenges for researchers like intermittency in load and weather, more integration of converters, system stability etc. Following such constraint it is chosen to study and work on energy management and intelligent system. Mostly researchers adopted the generalize concept to select the topic, but it requires study of particular area, load, weather and natural activities which are effect the system. Photovoltaic system efficiency is very low and can be increased by using some supplementary arrangement, smart monitoring devices and using Internet of Thing (IoT) technologies. Intelligent and smart energy management system will be able to setup a reliable and stable system.

4. Description of Topic

Intelligent/smart energy management is the way to extract maximum power from RES. Solar energy is also part of RES and it is easily available for each consumer between fixed time frame (summer and winter). Availability of solar energy converted to electric power by using solar cell/panel called it photovoltaic system. The efficiency of Polycrystalline structure base solar panel is around 15%, which is very less. MPPT is not much suitable for DC bus. Microgrid depends on power electronic converter to be optimally and configured.

Concentration of power electronic converter has been injecting harmonics and polluted the system. Intermittence in solar energy is main cause of system stability, reliability and compatibility of system (Like clouds, rain and weather conditions). Stability, adequacy, security and reliability are factor which affected by power integration to grid. To make system reliable, stable, optimal, and efficient and user friendly it required an intelligent EMS which is overcome the intermittency in PV system. System could be smart by using IoT concept and machine learning techniques.

5. Objectives/Methodology of Research

The proposed work is divided as per the following objectives:

1. To study of power quality issues in PV system.
2. To develop an intelligent/smart, innovative model for improving power quality and Energy Management.
3. To Modelling and Simulation of PV system along with control techniques.
4. To implement in real time the above model and verify the results.

Proposed smart PV system will study and develop as per IoT base energy management system. This proposal is divided into three segments -

Data Collection and Pre-processing: First stage of designing a model is collecting the data of the specified area, pre-processing and find the particular constraint which help to designing the model/concept.

Building the Model: Tune different parameters associated with the model and create an algorithm to make an intelligent system.

Simulation (MATLAB)/Experiment Setup: The system will work on collecting data and converting analog signals to digital signals. To achieve this it requires sensors for each device like current, voltage and weather sensors. The monitoring system consists of microcontroller/processor for accumulating information by getting each devices/sensors. The information provided from sensors is transferred to the main sever via internet. Internet provides communication medium between devices connected to network and each devices can be closely monitored and control the output of installed PV system. The devices will be use in proposed experiment model are microcontroller/processor, sensors (voltage and current), weather station communication media (internet).

The proposed research is to develop an efficient smart PV system which is controllable entity for the user side, and can meet load demands, reduce losses and provide local voltage stability by using IoT concept. PV system may connect to grid through power electronic converter to regulate the active, reactive power and output voltage to improve grid reliability.

6. Proposed/expected outcome of the research

The proposed research of energy management system based on IoT, maintain regulation/stability when PV system is unable to produce sufficient power to the connected load. It will minimize use of multilevel converter according to smart sockets, avoids injection of harmonics and higher end-to-end efficiency is achieved in the overall system.

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